

## METHOD FOR FORMING AN THIN FILM LIGHT EMITTING DEVICE

### CROSS-REFERENCE TO RELATED APPLICATION

5           This application claims the priority benefit of Taiwan application serial no. 90106034, filed on March 15, 2001.

### BACKGROUND OF THE INVENTION

#### Field of the Invention

10   [0001] The present invention relates to optoelectronics fabrication. Particularly, the present invention relates to a method for fabricating a thin film light emitting device, having a metal cathode with anti-oxidization function.

#### Description of the Related Art

15   [0002] The current optoelectronics technology has been successfully developed. The light emitting diode (LED) is one usual product of the optoelectrical devices. The light emitting diode can emit light when is applied with a bias. Thereby, the light emitting diode, associating with circuit design, can be incorporated in a display device, or providing as a light source. The light emitting diode has very wide applications.

20   [0003] In general, LED can be characterized into two types. One type is metal semiconductor LED and the other type is organic LED. The organic LED can further divided into two types. One is small molecular weight LED and the other one is polymer LED. The basic operations of these LED is that when a voltage of 2 volts to 10 volts is applied on the two electrodes, the organic LED then emitting light.

[0004] The mechanism for the organic LED to emit light is due to recombination of electrons and holes in the organic material. As electrons and holes recombine, energy is released in form of light. Usually, when a voltage is applied on the organic light emitting material, a ground state of the organic light emitting material transits to an excited state. At this condition, the organic light emitting material is at an unstable state and will fall back to the ground state from the excited state. At this moment, the electrons and the holes recombine and photons radiate out.

[0005] The brightness of the organic LED has strong dependency on the transmitted energy by the electrons and the holes. When the number of pairs of the electrons and holes for recombination is larger, the light brightness is higher accordingly. Theoretically, the organic light emitting material is a kind of organic semiconductor, the transit energy of the electron-hole pair is affected by the energy band of any contact material. For the cathode, electrons are transmitted from the metal cathode to the organic light emitting material. If the energy band between the cathode material and the organic light emitting material is larger, electrons are more difficult to transit to the organic light emitting material. Therefore, the metal material having smaller working function, such as Mg, Li, or Ca, is useful to reduce the energy band gap between the metal cathode and the organic light emitting material. As a result, the metal with small working function is helpful for transiting electrons to the organic light emitting material. This also means that the light emitting device has higher emitting efficiency.

[0006] FIG. 1 is a schematic drawing, illustrating a typical structure for an LED. In FIG. 1, there is a transparent substrate 50. A transparent anode layer 52, such as indium tin oxide (ITO), is formed on the substrate 50 thereon. An LED material layer 54 is formed on the transparent anode layer 52. A metal cathode layer 56 is formed on

the LED material layer 54. When a voltage is applied on the LED material layer 54, the lights 58 are emitted through the transparent substrate.

[0007] The metal cathode 56 usually includes a metal material with low working function, such as Ma, Li, or Ca, which metal materials basically are categorized as active metal. The active material is very easy to react with water or oxygen, resulting in degrading of performance of the metal cathode. Currently, the metal cathode of LED is usually made of active metal with low working function. Due to the active properties of the metal, the lifetime of production strongly depends on the amount of water or oxygen contained by the device. If the water or oxygen contained by the device is high, water and oxygen do react with the active metal cathode 56, causing the failure of the device. In order to ensure that the metal cathode is not eroded by water and oxygen, it needs a reliable package manner to package the device, so as to prevent the device from being eroded by water and oxygen.

[0008] Basically, the structure of device after packaging is shown in FIG. 2. After the metal cathode is accomplished, a sealant layer 60 is formed to cover a transparent anode 52, the LED material layer 54, and the metal cathode layer 56. Then, a cap layer 62 covers a portion of the sealant 60 above the metal cathode 56.

[0009] In order to solve the erosion of water and oxygen on metal cathode layer 56, the prior technology may add one additional material layer to reduce the reaction of the metal cathode with water and oxygen. However, the efficiency is still poor, or the method is more complicate.

## SUMMARY OF THE INVENTION

[0010] The invention provides a method for forming a thin film LED device. The method includes forming an active absorbing layer located on the cap layer of the LED device through vacuum evaporation manner. As the cap layer covers the LED device, the active absorbing layer can absorb invading water and oxygen. Consequently, water or oxygen has lower possibility to react with a metal cathode, and lifetime of device thereby can be effectively raised.

[0011] The invention provides a method for forming a thin film light emitting device by adding an insulating layer on the metal electrode before the device is packaged, so that the reaction between the metal cathode and water/oxygen is effectively reduced.

[0012] The invention provides a method for forming a thin film light emitting device. The method includes providing a transparent substrate. A transparent anode layer, a light emitting layer, a metal cathode layer are sequentially formed on the transparent substrate. A sealant layer is formed to at least cover the light emitting layer and the metal cathode layer. A covering layer having a covering surface is provided. An evaporation process is performed to form an active absorption layer on the covering surface of the covering layer. The covering surface of the covering layer covers on a portion of the sealant layer above the metal cathode layer.

[0013] In the foregoing step of providing the covering layer, the covering layer includes a cap-like layer to completely cover over the sealant layer, the transparent anode layer, light emitting layer, and the metal cathode layer.

[0014] In the foregoing, before the step of performing the evaporation process, the invention further includes forming a recess region on the covering surface of the

covering layer, whereby the active absorption layer is formed on a recessed surface of the recess region.

[0015] In the foregoing, the metal cathode includes Ca, Mg, or Li.

[0016] In the foregoing, the active absorption layer includes Ca, Mg, or Li.

5 [0017] The invention also provides another method for forming a thin film light emitting device. The method includes providing a transparent substrate. A transparent anode layer, a light emitting layer, a metal cathode layer are sequentially formed on the transparent substrate. An evaporation process is performed to form an active absorption layer at least covering the metal cathode layer. A sealant layer is formed at least covering the active absorption layer, the light emitting layer, and the metal cathode. A covering layer having a covering surface is provided. An evaporation process is performed to form an active absorption layer on the covering surface of the covering layer. A covering layer having a covering is provided. The covering surface of the covering layer covers on a portion of the sealant layer above the metal cathode layer.

[0018] The active absorption layer of the invention can effectively absorb invading oxygen or water, thereby the probability of reaction between metal cathode and water/oxygen is greatly reduced. The lifetime of product is then greatly prolonged.

20 [0019] The invention also provides another method for forming a thin film light emitting device. The method includes providing a transparent substrate. A transparent anode layer, a light emitting layer, a metal cathode layer are sequentially formed on the transparent substrate. An insulating layer is formed above the metal cathode layer. A sealant layer is formed to cover the insulating layer, the light emitting layer, the metal cathode layer, and the transparent anode layer. A covering

layer is provided. The covering layer covers a portion of the sealant layer above the metal cathode layer.

[0020] It is to be understood that both the foregoing general description and the following detailed description are exemplary, and are intended to provide further explanation of the invention as claimed.

# BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention. In the drawings,

[0022] FIG. 1 is a cross-sectional drawing, schematically illustrating a structure of a conventional LED device;

[0023] FIG. 2 is a cross-sectional drawing, schematically illustrating a packaging structure;

[0024] FIGs. 3A-3B are cross-sectional drawings, schematically illustrating a packaging structure of an LED, according to a preferred embodiment of the invention;

[0025] FIG. 4 is a cross-sectional drawing, schematically illustrating a packaging structure of an LED, according to another preferred embodiment of the invention;

[0026] FIGs. 5A-5B are cross-sectional drawings, schematically a packaging structure of an LED, according to another preferred embodiment of the invention;

[0027] FIGs. 6A-6B are cross-sectional drawings, schematically a packaging structure of an LED, according to still another preferred embodiment of the invention;

[0028] FIG. 7 is cross-sectional drawing, schematically a packaging structure of an LED, according to still yet another preferred embodiment of the invention;

[0029] FIG. 8 is cross-sectional drawing, schematically a packaging structure of an LED, according to still yet another preferred embodiment of the invention;

5 [0030] FIG. 9A is bottom view drawing, schematically a packaging structure of an LED, according to still yet another preferred embodiment of the invention; and

[0031] FIG. 9B is a cross-sectional drawing with respect to FIG. 9A.

### DESCRIPTION OF THE PREFERRED EMBODIMENTS

10 [0032] The invention particularly employs a vacuum evaporation process to deposit chemical active materials, such as active metal, onto a covering layer of a light emitting device to form an active absorption layer. As the covering layer covers over the metal cathode of the light emitting device, the active absorption layer can absorb invading water or oxygen, so as to avoid the erosion on the metal cathode and then prolong the

15 lifetime of the product. In the invention, the evaporation process used to for the absorption layer has rendered several features, One is that the material suitable for use in evaporation is usually hydrophilic and can absorb water or oxygen. As a result, the active absorption layer formed by evaporation process naturally has the property to absorb water or oxygen.

20 [0033] Moreover, the invention has also employed an insulating layer, formed on the metal cathode before it is packaged. In this manner, even though the absorption is not included, the insulating layer, due to the direct contact on the metal cathode, can also effectively isolate from water or oxygen. Several examples are provided in the following for describing the features of the invention.

[0034] FIGs. 3A-3B are cross-sectional drawings, schematically illustrating a packaging structure of an LED, according to a preferred embodiment of the invention. In FIG. 3A, like to FIG. 2, the LED device includes a transparent substrate 50, on which a transparent anode layer 52, such as indium tin oxide (ITO), is formed. An LED material layer 54 is formed on the transparent anode layer 52. A metal cathode layer 56 is formed on the LED material layer 54. A sealant layer 60 covers the transparent anode layer 52, the LED material layer 54, and the metal cathode layer 56. Then, a covering layer 62 covers a portion of the sealant layer 60 above the metal cathode layer 56. The covering layer 62 has an active absorption layer 64 above the metal cathode layer 56. The active absorption layer 64 has at least the properties of absorbing water or oxygen, whereby the invading water or oxygen is isolated, and the reaction of water or oxygen with the metal cathode layer 56 is avoided. The active absorption layer 64 includes, for example, Ca, Mg, or Li. In addition, the recess region 66 can prevent the active absorption layer 64 from direct contacting on the sealant layer 60.

[0035] The formation of the active absorption layer 64 is shown in FIG. 3B. In FIG. 3B, the covering layer 62 has a recess region 66 formed at the predetermined location by, for example, photolithographic and etching processes in semiconductor fabrication. The<sup>~</sup><sub>^</sub> a vacuum evaporation process is performed to evaporate the chemical active absorbing material onto the recess region 66, thereby to form the active absorption layer 64. Here, the use of evaporation process is one of features in the invention. [ Since the evaporation process has automatically ensure the material having ability to absorb water or oxygen. ] That is because the material suitable for use in evaporation process intrinsically has properties of absorbing water or oxygen. The evaporation process has effectively simplified the fabrication consideration.



[0036] Further still, FIG. 4 is a cross-sectional drawing, schematically illustrating a packaging structure of an LED, according to another preferred embodiment of the invention. In FIG. 4, a covering layer 70 is not necessary to have the active absorption layer. However, before the sealant layer 60 is formed, an active absorption layer 64 is evaporated beforehand to at least cover the metal cathode layer 56. The active absorption layer 64 may also cover the other portions, such as the transparent anode layer 52 and the LED material layer 54.

[0037] FIG. 5A-5B are cross-sectional drawings, schematically a packaging structure of an LED, according to another preferred embodiment of the invention. It is similar to the structure as shown in FIGs. 3A-3B, but the difference is that the covering layer 70 also needs no a recess region. Instead, the active absorption layer 64 is evaporated on the covering layer 70. As the covering layer covers over the sealant layer 60, the active absorption layer 64 directly contacts on the sealant layer 60.

[0038] FIGs. 6A-6B are cross-sectional drawings, schematically a packaging structure of an LED, according to still another preferred embodiment of the invention. In FIG. 6A, the covering layer 72 has a cap-like structure. The cap-like covering layer 72 can, for example, tightly covers the device elements on the transparent substrate. However, there is a recess region 74 on the cap-like covering layer 72, with respect to the metal cathode layer 56. An absorption layer 64 is formed within the recess region 74.

Alternatively as shown in FIG. 6B, the cap-like covering layer 72 is not tightly covering the device elements and leave a clearance. In this situation, the sealant layer 60 is formed to cover the device elements on the transparent substrate.

[0039] FIG. 7 is cross-sectional drawing, schematically a packaging structure of an LED, according to still yet another preferred embodiment of the invention. In FIG. 7, before

the sealant layer 60 is formed, an insulating layer 68 can be formed to cover the metal cathode layer 56. Then, the sealant layer 60 is formed afterward. The covering layer 70, as previously described, covers on the sealant layer 60. There is no need to form an active absorption layer on the covering layer 70. In other words, the method as shown in FIG. 7 needs no the active absorption layer. Instead, the insulation layer 68 directly covers the metal cathode layer 56, also resulting in prevention from contact with invading water or oxygen. Thereby, the insulating layer can also protect the metal cathode layer 56 from reacting with water or oxygen.

[0040] According to the invention, the covering layer can also be designed with various structure. FIG. 8 is cross-sectional drawing, schematically a packaging structure of an LED, according to still yet another preferred embodiment of the invention. The structure shown in FIG. 8 includes a substrate 50. A light emitting device 80 is formed on the substrate 50. The light emitting device 80 at least includes the transparent anode layer 52, the LED material layer 54, and the metal cathode layer 56 as previously described. Moreover, a sealant can also be included. In this embodiment, the difference is the structure of the covering layer 82. As the covering layer 82 is etched to form the recess region, the outer peripheral region of the device is also etched to form a trench <sup>86</sup>84. Likewise, an active absorption layer 64 is also formed with

of the device, when the device is finally cut, the edge would not be tidily cut, and even would cause damage of the device.

[0041] In the foregoing, the etching process on the covering layer, preferably, includes a sand jet process, which uses particles of aluminum oxide as the etchant to bombard the covering layer.

[0042] Further still, FIG. 9A is bottom view drawing, schematically a packaging structure of an LED, according to still yet another preferred embodiment of the invention. FIG. 9B is a cross-sectional drawing with respect to FIG. 9A. In FIG. 9A, an active absorption layer 64 is formed on the covering layer 90 at the predetermined location with respect to the light emitting device 80. Similarly to FIG. 8, this embodiment needs no the etching process. Instead, an inner frit line 94 and an outer frit line are coated at the periphery of the active absorption layer 64, in which there is a proper clearance between the inner and the outer frit lines.

[0043] In FIG. 9B, as the covering layer 90 covers over the light emitting device 80 on the substrate 50, sealant can be properly injected into the clearance between the frit lines 92 and 94. The structure of the clearance associating with proper amount of sealant 84, the sealant 84 can also be confined between the frit lines 92 and 94. This can also effectively prevent sealant from be overflowing outside. In this embodiment, the sealant and the frit lines also produces the needed space to cover the light emitting device 80.

[0044] In the foregoing, the invention can effectively prevent the metal cathode from reacting with invading water or oxygen, and thereby prolong the lifetime of the product. The method is simple also. Several advantages are as follows:

[0045] 1. The invention employs evaporation process to form an active absorption layer. Since the evaporation process is very suitable for materials that can absorb water or oxygen, such as Mg, Li, or Ca, the active absorption layer can be easily formed on the covering layer.

5 [0046] 2. The invention forms the active absorption layer as a part of the covering layer, where there is recess region so that the active absorption layer is not necessary to directly contact on the sealant layer.

[0047] 3. The invention forms the active absorption layer associating a cap-like covering layer. The cap-like covering can further protect the device.

10 [0048] 4. The invention uses an insulating layer, directly formed over the metal cathode 56. There is no of an active absorption layer.

[0049] 5. In addition, during etching the covering layer, a trench is also formed at the outer periphery of the device, so that exudation of sealant is avoided, and then the damage of the device during cutting process is also avoided.

15 [0050] 6. In addition, two close frit lines are formed at the peripheral region of the covering layer. By using the clearance of the frit lines in accordance with the amount of the sealant filled in the clearance, the covering layer adheres on the substrate, so as to protect the light emitting device.

20 [0051] It will be apparent to those skilled in the art that various modifications and variations can be made to the structure of the present invention without departing from the scope or spirit of the invention. In view of the foregoing, it is intended that the present invention cover modifications and variations of this invention provided they fall within the scope of the following claims and their equivalents.